Remarks

Claims 1-34 were pending in this Application. Claims 1-34 have been rejected under 35 U.S.C. 103(a) as being unpatentable over Rajavel in view of Han and Mitra of record. This Request for Continued Examination Amends Claims 13, 25, 26, 32 and 33; Cancels Claims 1-12, 19-24, 27-31 and 34; and Adds New Claim 69.

Claim Rejection 35 U.S.C. 103(a)

The Examiner states that

> Claims 1-34 are rejected under 35 U.S.C. 103(a) as being unpatentable over Rajavel in view of Han and Mitra.

Specifically

The Examiner states that

> Re claims 1, 2, 21, Rajavel 5,742,089 teaches multilayer structure comprising a silicon based substrate 14, epitaxial layer 18 including II-VI semiconductor material including combination of two binary alloys such as CdSe/ZnTe but lacks the specific recitation regarding the composition, e.g., of $Cd_{1-z}Zn_zSe_xTe_{1-x}$. The provision of overlayer 20, e.g., HgCdTe is also taught. See column 3 line 45 to column 8 line 65.
>
> Han 7,056471 61 teaches homogeneous II-VI quarternary alloys $M1_{-x}M_{2x}A_yB_{1-y}$ having improved characteristics and easy to produce, including the specific recitation of $Zn_{1-x}Cd_xSe_yTe_{1-y}$. The selection of the indices to be between zero and 1 is also taught. See the abstract, column 1 line 5 et seq., column 3 line 60 et seq., column 4 line 4 to column 9 line 65.
>
> It would have been obvious to one skilled in the art in practicing the above invention to have selected the quarternary compounds as claimed since such quarternary compounds are conventional, advantageous, and easy to produce as evidenced by Han. It would have been obvious and would have been within the purview of one skilled in the art to have selected the appropriate values of the indices x and z, given the teachings of Han evidencing the overlapping range. Additionally such variation would have been further obvious and advantageous as evidenced by Mitra, 6,208,005, column 5 line 60-65 wherein the variation of the alloy composition would have been conventional and obvious to obtain the desired film characteristics, e.g., desired bandgap.

Response

Applicant has Amended the Claims to Cancel claims 1 and 2 thus obviating the Rejection as to these two Claims. Applicant has Amended Claim 13 from which Claim 21 Depends to include the original limitations of Claim 1. Applicant Respectfully disagrees with the

Examiner that each and every element of limitation contained in Claim 21 as Depending from claim 13 as Amended would unpatentable (i.e., Obvious) over Rajavel in view of Han and Mitra. In particular, there is no requirement to be found in the three cited references that the $Hg_{1-y}Cd_yTe$ layer must be substantially lattice matched to the $Cd_{1-z}Zn_zX_xX'_{1-x}$ film. In particular Mitra uses a method of annealing to produce interdiffused layers of Hg based alloys. Mitra solves the problem of mismatched lattice constants by interposing a buffer layer that has a lattice constant substantially similar to, for example, HgTe. See Col 3, lines 31-36:

> A buffer layer 22 is formed on the surface of the substrate 20 by epitaxial growth. The layer 22 comprises $Cd_{1-y}Zn_yTe$ which is grown in a conventional manner. The layer 22 has a thickness in the range of 2-10 microns and a Zn mole fraction of 0.056 to achieve a lattice constant substantially similar to HgTe.

And Mitra Claim 1:

> A variable bandgap infrared absorbing semiconductor material structure, comprising:
> a substrate,
> a buffer layer epitaxially grown on said substrate, said buffer layer comprising cadmium zinc telluride, and
> a homogeneous alloy structure of mercury cadmium zinc telluride formed by epitaxial **growth on said buffer layer** of alternating layers of mercury telluride and cadmium zinc telluride, said cadmium zinc telluride layers and **said buffer layer having a zinc mole fraction to produce therein a lattice constant substantially similar to the lattice constant of said mercury telluride layers,** and wherein said mercury telluride and cadmium zinc telluride layers are annealed to form said homogeneous alloy structure. **(emphasis added)**

As Applicant stresses in its Application, the novelty of the instant invention is to solve the lattice mismatch in long wavelength HgCdTe devices. See paragraph [0004] line1-3:

> However, to advance this technology to long wavelength (LWIR, 8-12 μm) HgCdTe devices, **lattice matching to HgCdTe** is needed in order to reduce the dislocation density within the material. **(emphasis added)**

And paragraph [0008] lines 1-3:

> However, the prior art fails to disclose the MBE growth of high quality CdSeTe and CdZnSeTe films on a silicon based substrate, having low surface defect density **and potential lattice matching to HgCdTe.** In this context, a silicon based substrate is a substrate including a silicon layer, such as a silicon wafer, a passivated Si layer, or a Si layer supporting one or more further layers, such as ZnTe, CdTe and/or CdSeTe and or CdZnSeTe. There exists a need for

> high-quality CdSeTe or CdZnSeTe composite materials **that are lattice matched to $Hg_{1-y}Cd_yTe$** in the alloy composition range $0 \leq y \leq 1$. **(emphasis added)**

And paragraph [0047] lines 1-4:

> The X-ray FWHM generally increased as the x value of CdSeTe alloy increased. While only 4% of Se is necessary in CdSeTe composite substrate **to lattice match to LWIR HgCdTe,** other Se contents or the replacement of Se or Te by S are readily adopted to lattice match a variety of ternary materials. **(emphasis added)**

In fact, Applicant reported the unexpected results in paragraph [0048] lines 1-6 of the Application:

> Figure 6 shows an X-ray rocking curve of a 3-in $CdSe_{0.04}Te_{0.96}$/Si layer. The FWHM of a (422) diffraction peak from a 5.7-micron $CdSe_{0.04}Te_{0.96}$ layer is 103 arcsec (the right-hand peak of Figure 6). **This is believed to be the lowest value that has ever been reported for Si based composite substrate lattice matched to LWIR HgCdTe.** The left-hand peak shows the CdTe (422) diffraction peak, FWHM of 119 arcsec from the 6.5-micron layer underneath the CdSeTe layer. **(emphasis added)**

And in paragraph [0051] lines 4-6:

> The X-ray FWHMs of CdSeTe and CdZnSeTe are believed to be the lowest values that have ever been reported for Si based composite substrate **lattice matched** to LWIR HgCdTe. **(emphasis added)**

It is noted that Han 7,056,471 relates to nanocrystals consisting of a homogeneous ternary or quarternary alloy (abstract). The discussion of these nanocrystals focuses on the distinction over other nanocrystals. See Col 6, lines 39-54:

> As it can be seen from the properties of the nanocrystals of the invention, they constitute a novel class of nanocrystals. This holds true even for these ternary nanocrystals or nanoalloys of the invention that may have the same stoichiometric composition as the CdHgTe nanocrystals described by Harrison et al, supra (the stoichiometry of which is not known) the $Zn_yCd_{1-y}S$ system (with y=0.14, 0.15, 0.25, 0.34, 0.44, 0.61) and $Hg_yCd_{1-y}S$ system (with y=0.0025, 0.005, 0.05, 0.01, 0.2, 0.5, 0.75) described by Korgel and Monbouquette, supra, and the $Cd_xZn_{1-x}S$ (with x=0.95, 0.8, 0.72, 0.22, 0.10) nanoparticles described by Wang. Accordingly, the CdHgTe nanocrystals described by Harrison et al, and the $Zn_yCd_{1-y}S$ and $Hg_yCd_{1-y}S$ system described by Korgel and Monbouquette and the $Cd_xZn_{1-x}S$ nanoparticles described by Wang do not belong to the present invention.

In fact, the most pertinent reference to $Hg_xCd_{1-x}Se$ "Example 2" discusses that the nanocrystals were stored as a precipitate or dispersed in organic solvent. There is no discussion any where in the Patent of any possible use as a layer on a substrate to form a detector. There is no showing that the properties of the nanocrystals would be similar to the properties of such a compound conventionally produced as a thin film.

EXAMPLE 2

Synthesis of $Hg_xCd_{1-x}Se$ Nanocrystal Alloys Via One-Pot-Reaction Using $CdMe_2$ as Precursor

10 g of trioctylphosphine oxide and 5 g of hexadecylamine were loaded in a 50 ml three-neck flask and the mixture was dried and degassed in the reaction vessel by heating to about 150.degree. C. at about 1 Torr for about 1 h, flushing periodically with argon at least three times. The temperature of the reaction flask was then stabilized at 310.degree. C. with stirring under 1 atm of argon. At this temperature, 0.39 g (5.0 mmol) of selenium dissolved in 4.0 ml of TOP was added into the reaction system, followed by the quick injection of 1.0 mmol of $CdMe_2$ and then 1.0 3.0 mmol of $HgMe_2$. The system was then set at 270 310.degree. C. for growth of the alloy $Hg_xCd_{1-x}Se$ nanocrystals to reach a predetermined emission wavelength. After the alloy nanocrystals reached the desired emission wavelength, the heater was removed and the reaction mixture was cooled down to stop the reaction. When the temperature of the reaction mixture cooled to below 70.degree. C., the alloy nanocrystals were precipitated by adding about 15 ml of methanol. The precipitate was separated by centrifugation and decantation. Alloy nanocrystals were either stored as precipitate or dispersed in organic solvent (such as chloroform and toluene etc.) (see the $Hg_xCd_{1-x}Se$ PL and UV-vis spectra in FIG. 10)

Also in this case, use of, for example, a mixture of Se and Te dissolved in TOP yields quaternary alloys of the invention such as HgCdSeTe.

Rajavel 5,742,089 discloses $Hg_{1-x}Cd_xTe$ only as a buffer layer not as an actual epitaxial film layer grown as the semiconductor layer on the substrate as applicant has shown. (See Abstract line 5), Col 1, lines 56-64, which also mentions possible degradation of detector performance, Col 2, lines 49-55; Col 3, lines 49-50; Col 4, lines 25-34; Col 5, lines 65-66; Col 6, lines 49-67; Col 7, lines 48-54; and Claim 1, Col 8, lines 18-20 and 37-39. While the method claims for growing the ternary and quarternary films are withdrawn from the Claims in the instant Application, this does not change the fact that it is the disclosure of how the films are grown in such a way that the films are lattice matched to the substrate that provides the motivation for a person possessing ordinary skill in the art to use such films as the semiconductor layer.

Specifically

The Examiner states as follows:

> Re claims 3, 16, 28, the use of z being zero corresponds to the omission or minimization of Zn, such would have been obvious when x in Han is maximized and as shown in Rajavel, column 4 lines 14-15 when CdSe and CdTe are employed as the binary compounds thus obviating Zn. It is well settled that In the case where the claimed ranges "overlap or lie inside ranges disclosed by the prior art' a prima fade case of obviousness exists. In re Wertheim, 541 F.2d 257, 191 USPO 90 (CCPA 1976); In re Woodruff, 919 F.2d 1575, 16 IJSPQ2d 1934 (Fed. Cir. 1990) (The prior art taught carbon monoxide concentrations of "about 1-5%" while the claim was limited to more than 5%. The court held that 'about 1-5%" allowed for concentrations slightly above 5% thus the ranges overlapped.); In re Geisler, 116 Fad 1465, 1469-71, 43 IJSPQ2d 1362, 1365-66 (Fed. Cir. 1997). A prima facie case of obviousness exists where the claimed ranges and prior art ranges do not overlap but are close enough that one skilled in the art would have expected them to have the same properties. Titanium Metals Corp. of America v. Banner, 776 F.2d 775,227 USPQ 773 (Fed. Cir. 1985) "[A] prior art reference that discloses a range encompassing a somewhat narrower claimed range is sufficient to establish a prima fade case of obviousness.' In re Peterson, 315F.3d 1325, 1330, 65 USPQ2d 1379, 1382-83 (Fed. Cir. 2003). A range can be disclosed in multiple prior art references instead of in a single prior art reference depending on the specific facts of the case. Iron Grip Barbell Co., Inc. V. USA Sports, Inc., 392 F.3d 1317, 1322, 73 USPQ2d 1225, 1228 (Fed. Cir. 2004). The normal desire of scientists or artisans to improve upon what is already generally known provides the motivation to determine where in a disclosed set of percentage ranges is the optimum combination of percentages); In re Hoeschele, 406 F.2d 1403, 160 USPQ 809 (CCPA 1969).

Response

Applicant has Cancelled Claim 3 obviating the Rejection thereto. As described above, Applicant respectfully disagrees with the Examiner that Claim 16 Depending from Claim 13, which Applicant has herein Amended to include the limitations of Claim 1, and which requires a $Hg_{1-y}Cd_yTe$ layer being "substantially lattice matched to the $Cd_{1-z}Zn_zX_xX'_{1-x}$ film" is not patentable over Rajavel in view of Han and Mitra of record.

Specifically

The Examiner states as follows:

> Re claim 4, the use of an overlayer of CdX' corresponds to passvating [sic] layer 16 including Cd and Se or Te as shown in Rajavel, column 4 lines 1-5.

Re claim 6, the use of single crystal silicon substrate is well known in the art and is encompassed in Rajavel and as such would have been obvious.

Response
Applicant has Cancelled Claims 4 and 6 obviating the Rejections thereto.

Specifically

The Examiner states as follows:

Re claims 6-10, 15-18, 22, 26, 29, 33, such selection would have been obvious and would have been encompassed or overlapped in the range taught in Han as delineated above and in view of the optimization as suggested by Mitra above; it is well settled that in the case where the claimed ranges "overlap or lie inside ranges disclosed by the prior art" a prima fade case of obviousness exists. In re Wertheim, 541 F2d 257, 191 USPQ 90 (CCPA 1976); In re Woodruff, 919 F.2d 1575, 16 USPQ2d 1934 (Fed. Cir. 1990).

Response
Applicant has Cancelled Claims 6-10, 22 and 29 Obviating the Rejections thereto. As described above, Applicant respectfully disagrees with the Examiner that Claims 15-18 Depending Directly (Claim 16) or indirectly (Claims 15, 17 and 18) from Claim 13, which Applicant has herein Amended to include the limitations of Claim 1, and which requires a $Hg_{1-y}Cd_yTe$ layer being "substantially lattice matched to the $Cd_{1-z}Zn_zX_xX'_{1-x}$ film" are not patentable over Rajavel in view of Han and Mitra of record. Applicant has amended Claims 25 and 32 in a similar fashion to Claim 13; therefore Claim 26 Depending from Claim 25 and Claim 33 Depending from Claim 32 should be Allowable.

Specifically

The Examiner states as follows:

Re claims 11-12, 23, 24, 30, and claims depending therefrom, concerning the surface defect density, the Office is not equipped to measure the surface defect density in question, such would be inherent in or unpatentable over the prior art above, absent evidence to the contrary as the same layer or substantially similar material is obtained; it is well settled that once the claimed product appears to be the same or similar to that of the prior art, although produced by a different process, the burden shifts to applicant to come forward with evidence establishing an unobvious difference between the claimed product and the prior art product.

Response
Applicant has Cancelled Claims 11-12, 23, 24 and 30 Obviating the Rejections thereto.

Specifically

The Examiner states as follows:

> Re claims 13-14, 19, 20, 24, 25, 31, 32, and claims depending therefrom, the recitation of the overlayer such as cadmium chalcogenide $Hg_{1-}Cd-Te$ overlayer is also taught in Rajavel supra, layer 20/22, column 4 lines 25-58.

Response
Applicant has Cancelled Claims 19, 20, 24, and 31 obviating the Rejection thereto. As described above, Applicant respectfully disagrees with the Examiner that Claims 13, 25 and 32 which Applicant has herein Amended to include the limitations of Claim 1, Claims 21 and 24, and Claims 28 and 31 respectively, each of which requires a $Hg_{1-y}Cd_yTe$ layer being "substantially lattice matched to the $Cd_{1-z}Zn_zX_xX'_{1-x}$ film" is not patentable over Rajavel in view of Han and Mitra of record. Likewise, Claim 14 Depending from Claim 13 is also allowable.

Specifically

The Examiner states as follows:

> Re claims 27 and 34, these correspond to product-by-process feature and are deemed to be unpatentable over the prior art; it is well settled that for a product-by-process it is the patentability of the product which must be determined. "[E]ven though product-by-process claims are limited by and defined by the process, determination of patentability is based on the product itself. The patentability of a product does not depend on its method of production. If the product in the product-by-process claim is the same as or obvious from a product of the prior art, the claim is unpatentable even though the prior product was made by a different process" In re Thorpe, 777 F.2d 695, 696, 227 USPO 964, 966 (Fed. Cir. 1985) (citations omitted). Alternatively, such source for deposition is well known in the art and as such would have been obvious.

Response
Applicant has Cancelled Claims 27 and 34 Obviating the Rejections thereto.

New Claim

Applicant takes this opportunity to add new Claim 69 specifically drawn to one particular embodiment described in paragraph [0028] lines 8-14 complete with a limitation concerning the orientation of the Si substrate not previously Claimed in the pending Application.

Conclusion

Having Obviated each and every one of the Examiner's Rejections Applicant Respectfully requests that the Examiner Continue the Examination, enter the Amendments made herein and grant Allowance of the Application.

The Examiner is invited to telephone the undersigned at the local telephone number given below if, after considering this Amendment, the Examiner is of the opinion that the Amendments made by Applicant in this Amendment or in the Preliminary Amendment have not resolved all outstanding issues in this case and brought the case into Condition for Allowance.

Respectfully submitted,

5 OCTOBER 2007
DATE

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